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SCHOOL OF ENGINEERING

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JOINT SERVICE ELECTRONICS PROGRAM

RESEARCH IN ELECTRONICS

Contract No. F49620-85-C-0071

FINAL REPORT

For the period: 1 April 1985 through 31 March 1988

Presented to:

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Presented by:

University of Southern California
School of Engineering
Angeles, California 90089-0483

Principi Investigator: William H. Steier

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UNIVERSITY OF SOUTHERN CALIFORNIA
JOINT SERVICES ELECTRONICS PROGRAM
RESEARCH IN ELECTRONICS

Contract No. F49620-85-C-0071

Final Report

For the period: 1 April 1985 through 31 March 1988

This final report covers the period from April 1, 1985 through March 31, 1988 for The Joint Services Electronic Program at the University of Southern California, Contract No. F49620-85-C-0071

RESEARCH UNITS

During this period a total fourteen research units were supported. Twelve units were supported for entire three-year period. These units and the responsible scientists were:

In Solid State Electronics:

1. Heterojunction Materials and Devices Employing Ultrathin Layers Grown by Metalorganic Chemical Vapor Deposition (MOCVD) - P.D. Dapkus
2. Some Investigations of the Kinetics and Mechanisms of Molecular Beam Epitaxial Growth - A. Madhukar
3. Electrooptic Materials for Optical Processing and Computing Devices - A.R. Tanguay, Jr.

In Quantum Electronics:

4. Toward Room Temperature Lasers in the 3mm Wavelength Region - E. Garmire
5. A Spectroscopic Study of Basic Processes in Electrically Excited Materials - Martin Gundersen
6. Optical Switching - William H. Steier
7. Self-Pumped Optical Phase-Conjugating Laser Resonator Cavities - Jack Feinberg

In Information Electronics:

8. Analysis and Synthesis of Parallel Processing Systems - D. Moldovan and G. Bekey
9. Basic Research in C3 Distributed Databases - V.O.K. Li
10. Image Texture Restoration and Analysis using Nonstationary Models - A. A. Sawchuk
11. Reduced Modeling through Optimal Phase Matching - E.A. Jonckheere
12. Research in Computer Vision - Rama Chellappa

One research unit was supported during the period April 1985 through 31 March 1988:



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1. INFOBASE: An Information Management Environment for Personal Workstations - D. McLeod

One research unit was added for the period 1 April 1986 through 31 March 1988:

1. Electronic Surface Analysis using Non-Destructive Organic-on-Inorganic Semiconductor Contacts - S.R. Forrest

SIGNIFICANT RESEARCH ACCOMPLISHMENTS

Significant research accomplishments were reported in the following research units. For more details please see the annual reports.

In 1985:

1. Optimized MBE Growth Conditions for MQW Structures - A. Madhukar
2. Improvement in the High-Speed Time Response of Photorefractive Materials - J. Feinberg
3. Estimation of Object Motion Parameters from a Sequence of Noisy Images - R. Chellappa

In 1986:

4. Fundamental Limitations on the Photorefractive Recording Process - Armand R. Tanguay, Jr.
5. New Organic Materials for Rectifying Organic-Semiconductor Interfaces - S.R. Forrest
6. High To Low Threshold Lasers - E. Garmire

In 1987:

7. The Totally Planar Pnp Heterojunction Bipolar Transistor - P.D. Dapkus
8. The Transient Detection Microscope - Jack Feinberg -
9. Radio Frequency Electric Field Enhancement of Photorefractive Effects - W.H. Steier

Listed below are the numerous publications which have resulted from this research. The Ph.D. degrees awarded to students supported by this contract are also listed.

LIST OF PUBLICATIONS & Ph.D. THESIS

Solid State Electronics

Heterojunction Materials and Devices Employing Ultrathin Layers Grown by Metalorganic Chemical Vapor Deposition (MOCVD). P.D. Dapkus

Publications:

1. D. A. Sunderland and P. D. Dapkus, IEEE Electron Device Lett., EDL6, 648 (1985).

2. S. P. Den Baars, B. Y. Maa, P. D. Dapkus, A. D. Danner and H. C. Lee, *J. Crystal Growth*, **77**, 123 (1986).
3. D. A. Sunderland and P. D. Dapkus, *IEEE Trans. Electron Dev.* (Feb. 1987).
4. D. A. Sunderland and P. D. Dapkus, "Optimizing Npn and Pnp Heterojunction Bipolar Transistors for Speed," *Trans. Electron Dev.* **ED-34**, 367 (1987).
5. H. C. Lee, A. Hariz, P. D. Dapkus, A. Kost, M. Kawase, and E. Garmire, "Nonlinear Absorption in AlGaAs-GaAs Multiple Quantum Wells Grown By Metalorganic Chemical Vapor Deposition," *Appl. Phys. Letters* **50**, 118 (1987).
6. A. Kost, M. Kawase, E. Garmire, H. C. Lee, A. Hariz, and P. D. Dapkus, "Spectral Dependence and Diffusion Effects in the Nonlinear Absorption of GaAs/ AlGaAs Multiple Quantum Wells," *Proc. IQEC '87*, 30 (1987).
7. S. P. DenBaars, C. A. Beyler, A. Hariz, and P. D. Dapkus, "GaAs/AlGaAs Quantum Well Lasers with Active Regions Grown by Atomic Layer Epitaxy," *Appl. Phys. Letters* **51**, 1530 (1987).
8. H. C. Lee, K. Dzurko, P. D. Dapkus, and E. Garmire, "Electroabsorption in AlGaAs/GaAs Multiple Quantum Wells Grown on a Transparent GaP Substrate," *Appl. Phys. Lett.*, **51**, (1987).
9. H. C. Lee, A. Kost, M. Kawase, A. Hariz, P. D. Dapkus, and E. Garmire, "The Nonlinear Absorption Properties of AlGaAs/GaAs Multiple Quantum Wells Grown by Metalorganic Chemical Vapor Deposition," Invited Paper to be published in *IEEE J. Quant. Electron.*
10. A. D. Danner, P. D. Dapkus, A. Kost, and E. Garmire, "Nonlinear Absorption Coefficient of GaAs Doping Superlattices," To be Published in *J. Appl. Phys.*
11. A. Kost, E. Garmire, A. D. Danner, and P. D. Dapkus, "Nonlinear Optical Absorption in Quantum Well-NIPi Structures," Accepted for publication in *Appl. Phys. Letters*.
12. D. A. Sunderland, J. M. Haden, W. E. Stanchina, K. M. Dzurko, H. C. Lee, A. D. Danner, and P. D. Dapkus, "A Fully Planar PNP Heterojunction Bipolar Transistor," Accepted for publication in *Electron Devices Letters*.
13. S. P. DenBaars, A. Hariz, C. A. Beyler, B. Y. Maa, Q. Chen, and P. D. Dapkus, "The Growth of AlGaAs/GaAs heterostructures by Atomic Layer Epitaxy," *Proceedings of The Symposium on Semiconductor Multilayer Heterostructures*, Materials Research Society (1987).

Ph.D. Degrees Awarded:

1. D.A. Sunderland, "Modeling, fabrication and characterization of Pnp heterojunction bipolar transistors," 1987.
2. A.D. Danner, "Optical and opto-electronic properties of GaAs doping superlattices grown by MOCVD," 1988.
3. H.C. Lee, "The study of linear and nonlinear optical properties of GaAs-AlGaAs multiple quantum well structures grown by metalorganic chemical vapor deposition," 1987.

Some Investigations of the Kinetics and Mechanisms of Molecular Beam Epitaxial Growth, A. Madhukar

Publications:

1. P. Chen, J.Y. Kim, A. Madhukar and N.M. Cho, Jour. Vac. Sc. Tech. B4,890 (1986).
2. M.Y. Yen, T.C. Lee, P. Chen and A. Madhukar, Kinetics of the formation of normal and inverted molecular beam epitaxial interfaces: A RHEED dynamics study of GaAs/Al_xGa_{1-x}As(100) multiple quantum Wells, J. Vac. Sci. Tech., B (1986).
3. P. Chen, A. Madhukar, J.Y. Kim, and N.M. Cho, "The nature of surface migration during MBE growth of III-V compounds: a study via the RHEED specular beam intensity dynamics," Proc. 18th Int. Conf. Phys. Semiconductors, (Stockholm, Sweden, August 11-15, 1986) 1, 109 (1987).
4. F. Voillot, J.Y. Kim, W.C. Tang, A. Madhukar, and P. Chen, "Near band-edge luminescence studies of the effect of interfacial step distribution and alloy disorder in ultrathin GaAs/Al_xGa_{1-x}As(100) single quantum wells grown by MBE under RHEED determined conditions," Superlattices and Microstructures, 3, 313 (1987).
5. J.Y. Kim, P. Chen, F. Voillot, and A. Madhukar, "Photoluminescence and reflection high energy electron diffraction dynamics study of the interfaces in molecular beam epitaxially grown GaAs/Al_{0.33}Ga_{0.67}As (100) single quantum wells," Appl. Phys. Lett., 50, 739 (1987).
6. N.M. Cho, P. Chen, and A. Madhukar, "Specular beam intensity behavior in reflection high energy electron diffraction during molecular beam epitaxial growth of Al_{0.3}Ga_{0.7}As on GaAs(100) and implications for inverted interfaces," Appl. Phys. Lett., 50, 1909 (1987).
7. A. Madhukar, "Molecular Beam Epitaxial growth Kinetics, Mechanism(s) and Interface Formation: Computer Simulations and Experiments," Proc. NATO Adv. Res. Workshop., Scotland, September, 1986, Thin Film Growth Techniques for Low-dimensional structures, Ed. R.F.C. Farrow, et.al., (Plenum Publishing) p. 37, 1987.

Ph.D. Degrees Awarded:

1. Ming-Yuan Yen, "Some reflection high energy electron diffraction studies of molecular beam epitaxial growth of GaAs/Al_xGa_{1-x}As(100) interfaces and electron microscope studies of GaAs/Al_xGa_{1-x}As(100) and GaAs/InAs(100) semiconductor modulated structures," 1986.
2. Tzu-Chen Lee, "Studies of the growth kinetics and mechanisms during molecular beam epitaxial growth of Al_xGa_{1-x}As(100) and In_xGa_{1-x}As on GaAs(100) using RHEED intensity dynamics," 1986.
3. Joo Young Kim, "A comparative RHEED and photoluminescence study of heterointerfaces in GaAs/Al_{0.33}Ga_{0.67}As quantum wells grown via molecular beam epitaxy under RHEED determined growth conditions.

**Electrooptic Materials for Optical Processing and Computing Devices,
A. R. Tanguay, Jr.**

Publications:

1. A. Marrakchi, R. V. Johnson, and A. R. Tanguay, Jr., "Polarization Properties of Photorefractive Diffraction in Electrooptic and Optically Active Sillenite Crystals (Bragg Regime)," J. Opt. Soc. Am. B2, 321 (1986).
2. R. V. Johnson and A. R. Tanguay, Jr., "Optical Beam Propagation Method for Birefringent Phase Grating Diffraction," Opt. Eng. 25, 235-249 (1986). (Invited manuscript in Special Issue on Materials and Devices for Optical Information Processing.)
3. J. Yu, D. Psaltis, A. Marrakchi, A. R. Tanguay, Jr., and R. V. Johnson, "The Photorefractive Incoherent-to-Coherent Optical Converter", in Photorefractive Materials and Applications, J. P. Huignard and P. Gunter, Eds., Springer-Verlag, New York (in press).
4. R. V. Johnson and A. R. Tanguay, Jr., "Stratified Volume Holographic Optical Elements", Opt. Lett., 13(3), 189 (1988).
5. D. A. Seery, M. H. Garrett, and A. R. Tanguay, Jr., "Electrooptic Measurement of the Volume Resistivity of Bismuth Silicon Oxide ($\text{Bi}_{12}\text{SiO}_{20}$)", J. Cryst. Growth, 85, 289 (1987).
6. A. Marrakchi, R. V. Johnson, and A. R. Tanguay, Jr., "Polarization Properties of Enhanced Self-Diffraction in Sillenite Crystals", IEEE J. Quant. Electron., Special Issue on Electrooptic Materials and Devices, QE-23(12), 2142 (1987).
7. R. V. Johnson and A. R. Tanguay, Jr., "Fundamental Physical Limitations of the Photorefractive Recording Sensitivity for Grating Structures", in Optical Processing and Computing, H. Arsenault and T. Szoplik, Eds., Academic Press, New York, (1988); in press.

Ph.D. Degrees Awarded:

1. Abdellatif Marrakchi El Fellah, Real-Time Holography in Photorefractive Bismuth Silicon Oxide Crystals: Polarization Properties of Diffraction and Application to Spatial Light Modulation", University of Southern California, January, 1986.

Electronic Surface Analysis using Non-Destructive Organic-on-Inorganic Semiconductor Contacts - S.R. Forrest

1. S.R. Forrest, M. L. Kaplan, and P. H. Schmidt, "Organic thin films for semiconductor wafer diagnostics," invited chapter submitted to the Annual Reviews of Materials Science, 17, 1987, Annual Reviews, Inc.
2. F. F. So and S. R. Forrest, "Dependence of the Electrical Characteristics of Organic-on-Inorganic Semiconductor Contact Barrier Diodes on Organic Thin Film Composition", J. Appl. Phys., 63, 442 (1988).
3. S. R. Forrest and F. F. So, "Organic-on-Inorganic Semiconductor Heterojunctions: Energy Band Discontinuities, Quasi-Fermi Levels and Carrier Velocities", accepted for publication J. Appl. Phys (June, 1988).

4. F.F. So and S.R. Forrest, "Measurement of the valence band discontinuities for molecular organic semiconductor/inorganic semiconductor heterojunctions," Appl. Phys. Lett., 52, 1341 (1988).

Quantum Electronics

Toward Room Temperature Lasers in the 3mm Wavelength Region, E. Garmire

Publications:

1. E. Garmire, "Tolerances of Locked Semiconductor Laser Arrays." Proc. of S.P.I.E., January 1988.
2. T. C. Hasenberg and E. Garmire, "Low Threshold High T_0 InGaAsP/InP 1.3mm Lasers grown on p-type InP Substrates", Appl. Phys. Lett., 49, 400 (1986).
3. T. Hasenberg and E. Garmire, "An improved Au/Be contact to p-InP," J. Appl. Phys., 61, 808 (1987).
4. T. Hasenberg and E. Garmire, "Characteristics of InGaAsP/InP p-DCC lasers grown by three-melt technique," IEEE J. Quant. Elect., QE-23, 948 (1987).
5. N. M. Jokerst and E. Garmire, "The depletion region electric-field absorption modulator," submitted to Appl. Phys. Lett., November 1987.
6. H.C. Lee, A. Hariz, P.D. Dapkus, A. Kost, M. Kawase, and E. Garmire, "Nonlinear absorption in AlGaAs/GaAs multiple quantum well structures grown by metalorganic chemical vapor deposition," Appl Phys. Lett., 50, 1182 (1987).
7. H.C. Lee, K.M. Dzurko, P.D. Dapkus, and E. Garmire, "Electro-absorption in AlGaAs/GaAs multiple quantum well structures grown on GaP transparent substrate," Appl. Phys. Lett., 51, (1987).
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Ph.D. Degrees Awarded:

1. T. C. Hasenberg, "Low threshold, High T_0 InGaAsP/InP 1.3 mm Lasers Grown on p-type InP Substrates with a three-Melt Technique," May 1986.

A Spectroscopic Study of Basic Processes in Electrically Exited Materials, M. Gundersen

Publications:

1. D.A. Erwin and J.A. Kunc, "Electron temperature and ionization degree dependence of electron transport coefficients in monatomic gases," Phys. Fluids 28, 3349 (1985).

2. D.A. Erwin and J.A. Kunc, "Electron temperature and ionization degree dependence of the electrical conductivity in diatomic gases," *Phys. Fluids* **30**, 919 (1987).
3. "Summary of the workshop for research issues in power conditioning," M.A. Gundersen, editor, University of Southern California (1986).
4. H-H. Dai, M.A. Gundersen, and C.W. Myles, "A semi-empirical formalism for the calculation of deep level wavefunctions in k space," *Phys. Rev. B* **33**, 8234 (1986).
5. D.A. Erwin and M.A. Gundersen, "Measurement of excited-state densities during high-current operation of a hydrogen thyatron using laser-induced fluorescence," *Appl. Phys. Lett.* **48**, 1773 (1986).
6. D.A. Erwin, J.A. Kunc and M.A. Gundersen, "Determination of electric field and electron temperature in the positive column of a high-power hydrogen thyatron from non-intrusive measurements," *Appl. Phys. Lett.* **48**, 1727 (1986).
7. G.F. Kirkman and M.A. Gundersen, "A low pressure, light initiated, glow discharge switch for high power applications," *Appl. Phys. Lett.* **49**, 494 (1986).
8. J.A. Kunc, D. Erwin, and C. Braun, "Fundamental processes in high current glow discharge switches," M.A. Gundersen, *Proceedings Elektronenröhren und Vakuumelectronik, NTG-Fachberichte* **95**, 94 (1986).
9. M.A. Gundersen, R. DeWitt, A.K. Hyder, C.R. Jones, J.A. Kunc, M.J. Kushner, E.P. Muntz, G. Schaefer, and P.F. Williams, "Research issues in power conditioning," *Proceedings 1986 Seventeenth Power Modulator Symposium*, Hyatt Seattle, Seattle, Washington, June 23-25, 1986.
10. C.G. Braun, D.A. Erwin, G.F. Kirkman, and M.A. Gundersen, "A linear thyatron for developmental research," *Proceedings 1986 Seventeenth Power Modulator Symposium*, Hyatt Seattle, Seattle, Washington, June 23-25, 1986.
11. H. Dai, C. W. Myles and P. G. Snyder, "Phonon assisted indirect recombination of bound excitons in N-doped GaP, including near resonant processes," *Phys. Rev. B* **37**, 1205 (1988).
12. C. G. Braun, D. A. Erwin and M.A. Gundersen, "Fundamental processes affecting recovery in hydrogen thyatrons," *Appl. Phys. Lett.* **50** (19), 1325 (1987).
13. K. Frank, E. Boggasch, J. Christiansen, A. Goertler, W. Hartmann, C. Kozlik, G. Kirkman, C. G. Braun, V. Dominic, H. Riege and M.A. Gundersen, "High power hollow electrode thyatron-type switches," *Proceedings, Sixth IEEE Pulsed Power Conference*, 213, June 1987.
14. K. Frank, E. Boggasch, J. Christiansen, A. Goertler, W. Hartmann, C. Kozlik, G. Kirkman, C. G. Braun, V. Dominic, M.A. Gundersen, H. Riege and G. Mechttersheimer, "High power hollow electrode thyatron-type switches," *IEEE Trans. Plasma Science*, Vol. **16** (2) (1988).
15. C.G. Braun, W. Hartmann, V. Dominic, G. Kirkman, M. Gundersen and G. McDuff, "Fiber optic triggered high-power low-pressure glow discharge switches," *IEEE Trans. Electron Devices*, Vol. **35**, (4), 559 (1988).

16. G. Kirkman, W. Hartmann, and M.A. Gundersen, "A flashlamp triggered high power thyatron type switch with remarkable plasma characteristics," *App. Phys. Lett.* 52, 613 (1988).
17. M.S. Choi, J.H. Jur, and M.A. Gundersen, "An optoelectronic bistability in gallium phosphide," *App. Phys. Lett.*, accepted.

Ph.D. Degrees Awarded:

1. Daniel A. Erwin, "Characterization of hydrogen thyatron positive column plasmas," 1986.
2. Christopher G. Braun, "An investigation of non-equilibrium argon and hydrogen plasmas," 1986.

Optical Switching, W.H. Steier

Publications:

1. G. Albanese, J. Kumar, and W. H. Steier, "Investigation of the photorefractive behavior of chrome-doped GaAs by using two-beam coupling," *Optics Lett.*, 11, 650 (1986).
2. J. Kumar, G. Albanese, and W.H. Steier, "Photorefractive two -beam coupling with applied radio frequency fields: Theory and experiments" *JOSA B*, 4, 1079 (1987).
3. J. Kumar, G. Albanese, W.H. Steier, and M. Ziari, "Enhanced Two Beam Mixing Gain in Photorefractive GaAs using Alternating Electric Fields," *Optics Lett.*, 12, 120 (1987).
4. J. Kumar, G. Albanese, and W.H. Steier, "Measurement of Two-wave Mixing Gain in GaAs with a Moving Grating," *Optics Comm.*, August, 1987.

Self-Pumped Optical Phase Conjugating Laser Resonator Cavities, J. Feinberg

Publications:

1. K.R. MacDonald and J. Feinberg, "Enhanced four-wave mixing by use of frequency-shifted optical waves in photorefractive BaTiO₃," *Phys. Rev. Lett.*, 55, 821 (1985).
2. S. Ducharme and J. Feinberg, "Altering the photorefractive properties of BaTiO₃ by reduction and oxidation," to be published in *J. Opt. Soc. of America B*, February 1986.
3. Feinberg and G.D. Bacher, "Phase-locking lasers with phase conjugation," *Appl. Phys. Lett.* 48, 570 (1986).
4. S. Ducharme and J. Feinberg, "Altering the photorefractive properties of BaTiO₃ by reduction and oxidation at 650°C," *J. Opt. Soc. Amer. B* 3, 283 (1986).
5. J.P. Jiang and J. Feinberg, "Dancing modes and frequency shifts in a phase conjugator," *Optics Letters* 12, 266-268 (1987)
6. S. Ducharme, J. Feinberg, and R.R. Neurgaonkar, "Electrooptic and piezoelectric measurements in photorefractive barium titanate and strontium barium niobate," *IEEE J. Quantum Electronics*, QE-23, 2116 (1987).

7. R.S. Cudney, R.M. Pierce, and J. Feinberg, "Transient Detection Microscope," *Nature*, **332**, 424 (1988).

Ph.D. Degrees Awarded:

1. Steve Ducharme, 1987
2. Ken MacDonald, 1987

Information Electronics

Analysis and Synthesis of Parallel Processing Systems, D.I. Moldovan

1. D.I. Moldovan and Y.W. Tung, "SNAP: A VLSI Architecture for Artificial Intelligence Processing", *J. Par. Dist. Comp.*, **2**, No. 2 (1985).
2. J.A.B. Fortes and D.I. Moldovan, "Parallelism detection and algorithm transformation techniques useful for VLSI architecture design," *J. Par. Dist. Comp.*, **2** No. 3 (1985).
3. T.C. Lin and D.I. Moldovan, "Tradeoffs in mapping algorithms into array processors," *Proc. 1985 Int'l. Conf. on Par. Proc.*, August, 1985.
4. F. Tenorio and D.I. Moldovan, "Mapping production systems into multiprocessors," *Proc. 1985 Int'l. Conf. on Par. Proc.*, August, 1985.
5. D.I. Moldovan and J.A.B. Fortes, "Partitioning of Algorithms for Fixed Size VLSI Architectures," *IEEE transactions on Computers*, **C-35**, No.1, (1986).
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7. D.I. Moldovan, "Systolic array for optimal binary research three algorithm, *Proc. 20 Hawaii Int. Conf. Systems Sciences*, Jan. 1987.
8. D.I. Moldovan, "RUBIC; multiprocessor for rule-based systems," to appear in *IEEE Trans. on Sys. Man and Cybernetics*, 1988.
9. D.I. Moldovan and C.I. Wu, "Parallel processing of knowledge based visions systems," to appear in *IEEE Trans on Software Eng.*, 1988.

Basic Research In C3 Distributed Data Bases, V.O.K. Li

Publications:

1. A.L.P. Chen and V.O.K. Li, "An optimal algorithm for processing distributed star queries," *IEEE Trans. on Software Engineering*, **SE-11**, 1097 (1985).
2. Y.F. Lam and V.O.K. Li, "Reliability Modeling and analysis of communications networks with dependent failures," *Proc. IEEE INFOCOM*, Washington, D.C., March 1985.
3. C.P. Wang and V.O.K. Li, "The relation-partitioning approach to query processing in distributed databases." *Proc. IEEE Data Engineering Conf.*, Los Angeles, CA February 1986.

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5. Shyu, S.C. and Li, V.O.K., "Performance analysis of static locking in distributed database systems." Submitted to ACM SIGMETRICS.
6. Huang, C.L. and Li, V.O.K., "A High-Availability Quorum-Based Termination Protocol for Distributed Database Systems." IEEE Trans. on Comp. (undergoing revision).
7. Chen, J.S.J. and Li, V.O.K., "Optimizing Joins in Fragmented Database Systems on a Broadcast Local Area Network." To appear in the IEEE Trans. on Software Engineering.
8. Huang, C.L. and Li, V.O.K., "A Quorum-Based Termination Protocol for Distributed Database Systems," Proc. IEEE Data Engineering Conference, Culver City, California, February 1988.
9. Wang, C.P. and Li, V.O.K., "A Unified Concurrency Control Algorithm for Distributed Database Systems," Proc. IEEE Data Engineering Conference, Culver City, California, February 1988.
10. Li, V.O.K., "Performance Models of Timestamp-Ordering Synchronization Algorithms in Distributed Databases," IEEE Trans. on Computers, C-36(9), 1041 (1987).
11. Chen, S.J. and Li, V.O.K., "Optimizing Joins in Fragmented Database Systems on a Broadcast Local Area Network," Proc. IEEE International Conference on Distributed Computing, Berlin, Germany, September 1987.
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